To

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THE SYDNEY COUNTY COUNCIL

BRANCH STANDING INSTRUCTION

SECTIONAL
(Procedure)

No. 1207
Index No. 614.314
614.324
Date 15.5.69

BRANCH METER.

SECTION TESTING.

SUBJECT METER INSTALLATION - CHECKING OF LOW VOLTAGE CURRENT TRANSFORMER METERING CONNECTIONS FOR SINGLE PHASE AND POLYPHASE METERS.

OBJECTIVE To set out the method for checking low voltage current transformer metering connections for single phase and polyphase meters.

This Instruction supersedes and cancels Branch Standing Instruction No. 1207 dated 11th December, 1968.

MEANS OF ATTAINMENT.

1. GENERAL.

The metering connections shall be checked and a current transformer ratio and polarity test shall be carried out in all new or altered low voltage current transformer metering installations and in all cases where the accuracy of the metering is queried by a customer. Where the meter is queried by the Treasury Branch and the query cannot be satisfactorily explained, a full connection check, as set out in this Instruction shall be carried out. If the reason for the query can be readily explained and a full connection check, including ratio and polarity tests, has been previously carried out it will not be necessary to repeat these tests. When a meter is changed by Meter Branch staff as a routine matter, it will only be necessary to carry out the tests detailed in Clause 8 provided that a full connection, ratio and polarity check has previously been carried out.

2. METERING CONNECTIONS.

Figure 1 attached to this Instruction shows the standard connections and colour coding (B.S.I. No. 1208) for current transformers and test blocks. The connections between the test block and the meter(s) may be as shown, or the colour coding may be "blue", "yellow" and "red" from left to right at the meter(s).

A recent change in procedure by staff of the Electrical Installation Branch sets out that in new installations the meter shall be connected "red", "yellow" and "blue" from left to right. If supply is available, Connecting Officers will check the phase sequence at the meter and if found to be incorrect will transpose the connections of the left and right hand elements.

In new installations, sufficient length of wire will be left behind the meter board and any transposition shall be made behind the board.

Figure 2 attached to this Instruction shows the standard terminal arrangement for multi-ratio current transformers.

3. CHECK OF CURRENT TRANSFORMERS FOR CORRECT SIZE.

Check that the size, as marked on the current transformer, corresponds with the size or reading constant as shown on the nameplate of the corresponding meter and on the test card. If unable to visually check the size marked on the current transformer, or if there is any doubt as to the ratio, measure the secondary current by connecting an ammeter in the secondary circuit of the current transformer and simultaneously measure the primary current with a tong test set.

4. CHECK OF POTENTIAL WIRING.

(a) Check test lamps.

(b) Check with test lamps that the 240 volt supply is available at the fuses and at each meter and/or at each phase of the polyphase meter.

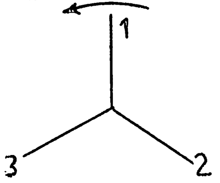
Note: Fuses shall be of the 10 ampere rating.

(c) Check the phase sequence at the meter or meters (See B.S.I. No. 1015). Correct phase sequence at the meter or meters for new metering installations should be anti-clockwise.

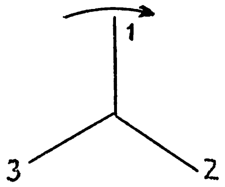
If the phase sequence of a polyphase meter at a new installation is clockwise, transpose the connections behind the meter board, of the left and right hand elements. Re-check phase sequence. See note for old installations.

Where a time switch or timer is associated with the meter, check that the motor supply voltage is of the same phase as that connected to the left hand element of the meter. If this is not the case, change the motor supply voltage to the appropriate phase. An additional link is provided in all new installations for this purpose.

The phase sequence shall be recorded on the Meter Test Card in the space immediately above the "Meter Removed" column, and shall be indicated as follows:-



OR



Note: For metering installations installed prior to 1959, the phase sequence at the meter or meters will probably be clockwise. In this case the phase sequence shall not be altered unless it is necessary to change the polyphase meter; the replacement meter shall be connected for anti-clockwise sequence.

5. CHECK OF CURRENT TRANSFORMER WIRING AND CORRECT PHASING.

(a) Short circuit the secondary winding of each current transformer at the secondary terminals of the current transformer. In the case of multi-ratio current transformers this may be done by bridging any two (2) secondary terminals.

(b) The polarity terminal of a current transformer is denoted by a distinguishing colour, such as white or yellow. The secondary wiring shall be colour coded in accordance with B.S.I. No. 1208. If during the subsequent tests the colour coding is found to be incorrect it shall be corrected.

(c) Disconnect the "R" phase "polarity" wire at the current transformer, and disconnect the "R" phase current line wire at the energy meter.

Energise the "R" phase polarity wire from the corresponding phase voltage, and check with test lamps that -

(i) Supply is available at the line or polarity wire (colour coded red) of the "R" phase energy meter or the "R" phase element of a polyphase meter.

(ii) Supply is available at the correct terminal of the test block, i.e. the left hand current link.

(iii) "Y" and "B" phase line wires and all load wires at the energy meter or meters are not energised.

(iv) The "R" phase "polarity" wire and its associated voltage wire at the meter are of the same phase. For this test, the lamps should not light as the wires being tested should be at the same potential, If the "R" phase polarity wire is found to be correct, reconnect it at the current transformer and reconnect the "R" phase line wire at the meter.

(d) Disconnect the "R" phase non-polarity wire at the current transformer and disconnect the "R" phase current load wire at the energy meter. Energise the "R" phase non-polarity wire from the corresponding phase voltage and check with test lamps that -

(i) Supply is available at the load or non-polarity wire (colour coded red/white) of the "R" phase energy meter, or the "R" phase element of a polyphase meter.

(ii) Supply is available at the correct terminal of the test block, i.e. the second current link from the left.

(iii) "Y" and "B" phase line and load wires at the energy meter or meters are not energised.

If the "R" phase non-polarity wire is found to be correct, reconnect it at the current transformer and reconnect the "R" phase current load wire at the meter.

(e) Identify each of the four (4) remaining secondary current wires in a similar manner to that set down in 5 (c) or 5 (d) with the exception that the colour coding and the associated current link at the test block shall be in accordance with fig. 1 attached.

6. CHECK OF CURRENT TRANSFORMER RATIO.

(a) Examine the current transformers (multi-ratio type) to ensure that they conform to details shown in Figure 2.

Report any non-standard features to the Supervisor.

(b) If suitable customer's load is available, check the ratio of the current transformers by comparing the primary and secondary currents. If customer's load is not available connect the auxiliary loading equipment provided. Under no circumstances, when connecting the auxiliary load equipment, shall a lead be passed through the window of a current transformer.

7. CHECK OF CURRENT TRANSFORMER POLARITY AND CHECK OF METER FOR CORRECT ROTATION.

This test shall be carried out with auxiliary load in addition to customer's load or with auxiliary load only. The auxiliary load must be connected on the load side of the current transformers.

(a) Single Phase Meters.

(i) Remove "R", "Y" and "B" phase metering voltage fuses in turn and observe that the corresponding meter stops.

(ii) Replace all fuses and check the rotation of the meter discs.

The forward speed of the meter disc should increase when the auxiliary load is "ON". If a meter disc rotates in the reverse direction with customer's load it should (with correct connections) rotate in a forward direction or less quickly in a reverse direction when the auxiliary load is "ON".

(b) Polyphase Meters.

(i) Remove "R", "Y" and "B" phase metering voltage fuses and observe that the meter stops.

(ii) Replace each fuse in turn so that only one fuse is connected at any time and check the rotation of the meter disc. The forward speed of the meter should increase when the auxiliary load is "ON". If the meter disc rotates in the reverse direction with customer's load it should (with correct connections) rotate in a forward direction or less quickly in a reverse direction when the auxiliary load is "ON".

If, in any of the above tests, it is observed that the meter disc rotates in the reverse direction, check whether the customer has any 415 volt single phase load connected such as a 415 volt welder. If such is the case, a record shall be made on the meter test card.

In some cases, the customer's load may be fluctuating or of such magnitude that the addition of the auxiliary load does not permit, with absolute certainty, the observation of a change of rotor speed. If arrangements can be made with the customer to vary his load, to enable a satisfactory "added auxiliary load" test to be carried out, this shall be done.

Where this cannot be arranged, a slight modification to the "Polyphase Field Test Equipment" can be made to enable a satisfactory test to be performed. The Appendix to this Instruction details the connections and method for conducting this test.

If any uncertainty exists as to the validity of any of the above tests, the matter shall be referred to the Supervisor.

8. CONNECTION CHECK AFTER A METER IS CHANGED BY METER BRANCH STAFF.

The following procedure shall only apply after a meter has been changed by Meter Branch Staff and where the Test Cards indicate that the connections of the installation have been previously checked.

It is a prerequisite that the metering voltage fuses are withdrawn, the secondary current circuits are bridged at the test block and the test links at the test block are open.

(a) Insert the "R" fuse and from the meter terminals energise the special 3 amp. load box provided. Apply the output test prods of the special load box to the appropriate current terminals of the test block and observe that the meter disc revolves in a forward direction. It is essential that the red alligator clip is connected to the energised voltage terminal at the meter and that the red test prod is connected to the polarity current terminal at the test block.

(b) Withdraw the "R" fuse, insert the "Y" fuse and repeat the test as in (a).

(c) Withdraw the "Y" fuse, insert the "B" fuse and repeat the test as in (a).

(d) Replace all fuses, check phase sequence at the meter and proceed with the meter test as in Clause 9.

9. TEST OF METER.

After every connection check, the meter shall be tested at 0.25 amps. and 5.0 amps. at unity power factor and at 5.0 amps. at 0.5 lagging power factor. The demand section of an energy demand meter shall only be tested on a customer's excessive account query or when specifically requested by the Treasurer.

10. CHECK OF TERMINALS.

Check that all metering connections are tight, observe that movable links of test blocks are in the closed position, that no bridges remain on any part of the current circuits and that all fuses are intact. Seal all equipment.

11. RECORDING.

If all tests are satisfactory, record in the "Metering Connections Test" column of the test card "Correct". Record also "Ratio and Polarity Correct".

Should any incorrect connections or incorrect ratio and polarity be found, a separate report setting out the details and the corrective action taken, shall be forwarded to the Supervisor, who shall inform the Electrical Installation Superintendent of the details by means of an M.S.14 form.

12. ATTACHMENTS TO THIS INSTRUCTION.

(a) Fig. 1. - Low Voltage Current Transformer Metering Connections to various types of Test Blocks.

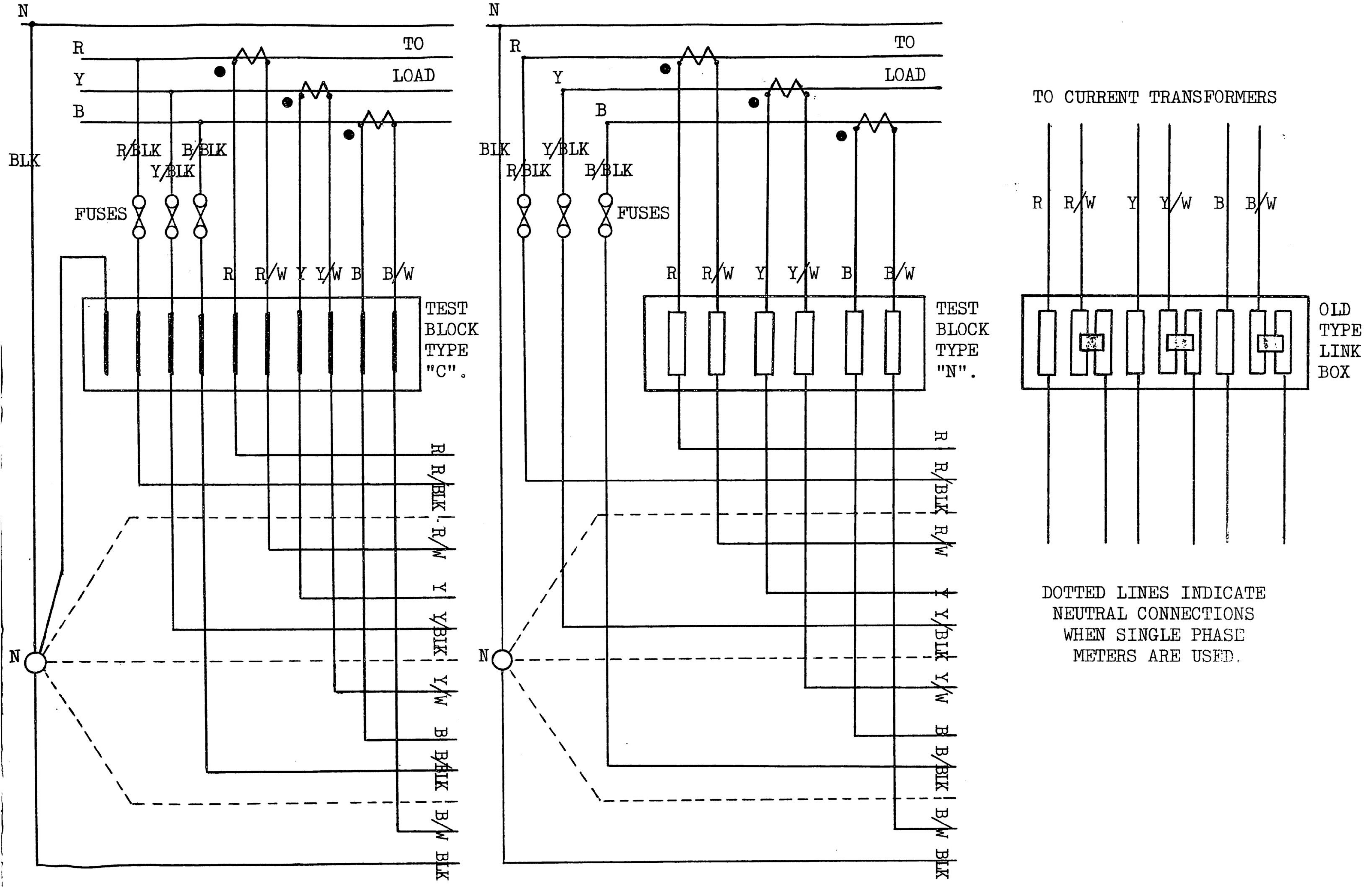
(b) Fig. 2. - Low Voltage Multi-Ratio Current Transformers - Secondary Terminals, Name Plate and Polarity Mark Details.

(c) Appendix 1. Modification of Polyphase Test Equipment for checking of Metering Connections.

METER SUPERINTENDENT

ATTACHMENT TO BRANCH STANDING INSTRUCTION NO. 1207

LOW VOLTAGE CURRENT TRANSFORMER METERING CONNECTIONS TO VARIOUS TYPES OF TEST BLOCKS



DOTTED LINES INDICATE
NEUTRAL CONNECTIONS
WHEN SINGLE PHASE
METERS ARE USED.

Fig. 1

ATTACHMENT TO BRANCH STANDING INSTRUCTION NO. 1207.

Low Voltage Multi-Range Current Transformers.
Secondary Terminals, Nameplate and Polarity Mark Details.

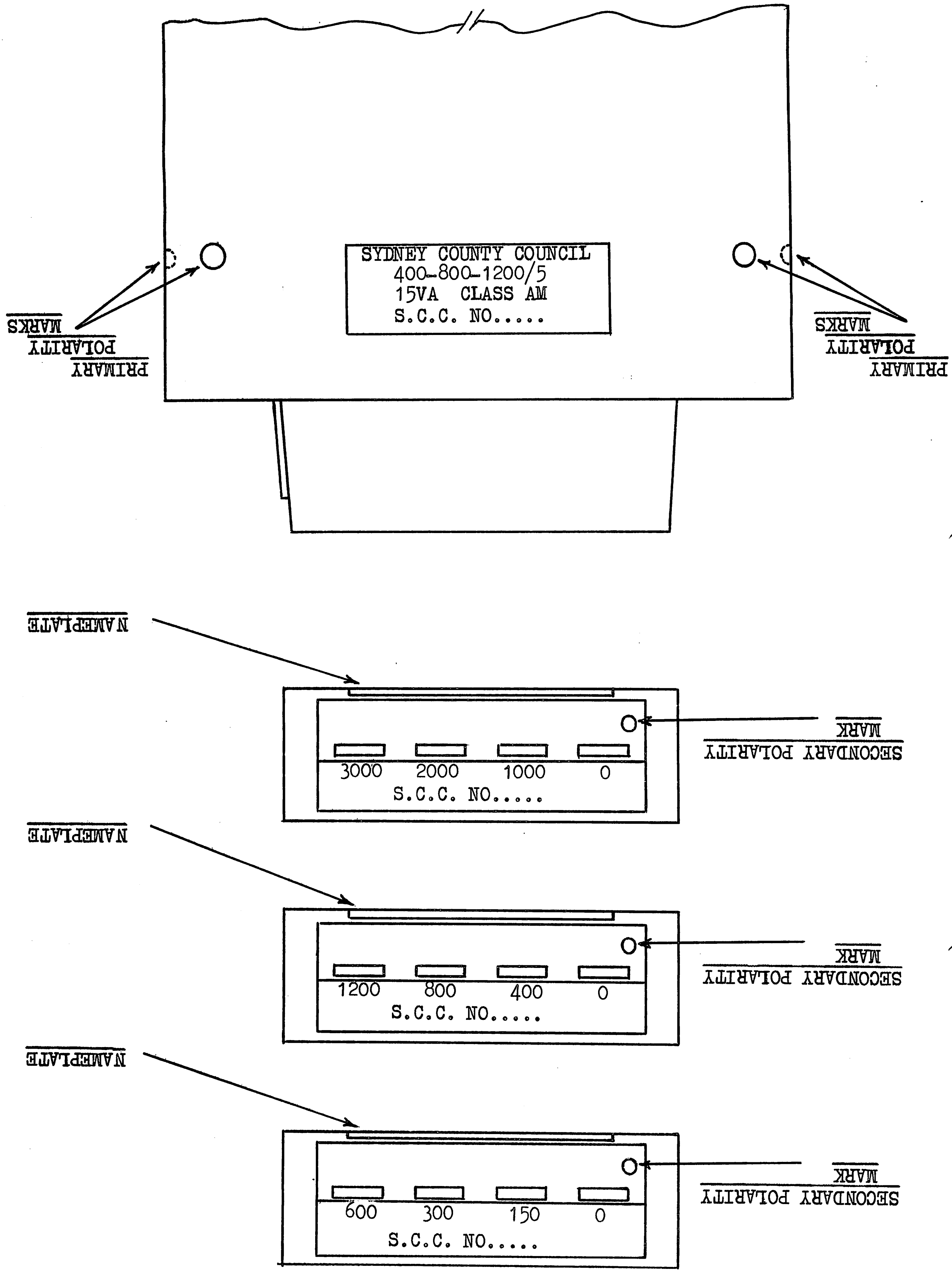


FIG. 2.

ATTACHMENT TO BRANCH STANDING INSTRUCTION NO. 1207.

THE CONVERSION AND USE OF THE L.V. POLYPHASE TEST EQUIPMENT AS AN "ON LOAD" CONNECTION CHECKER.

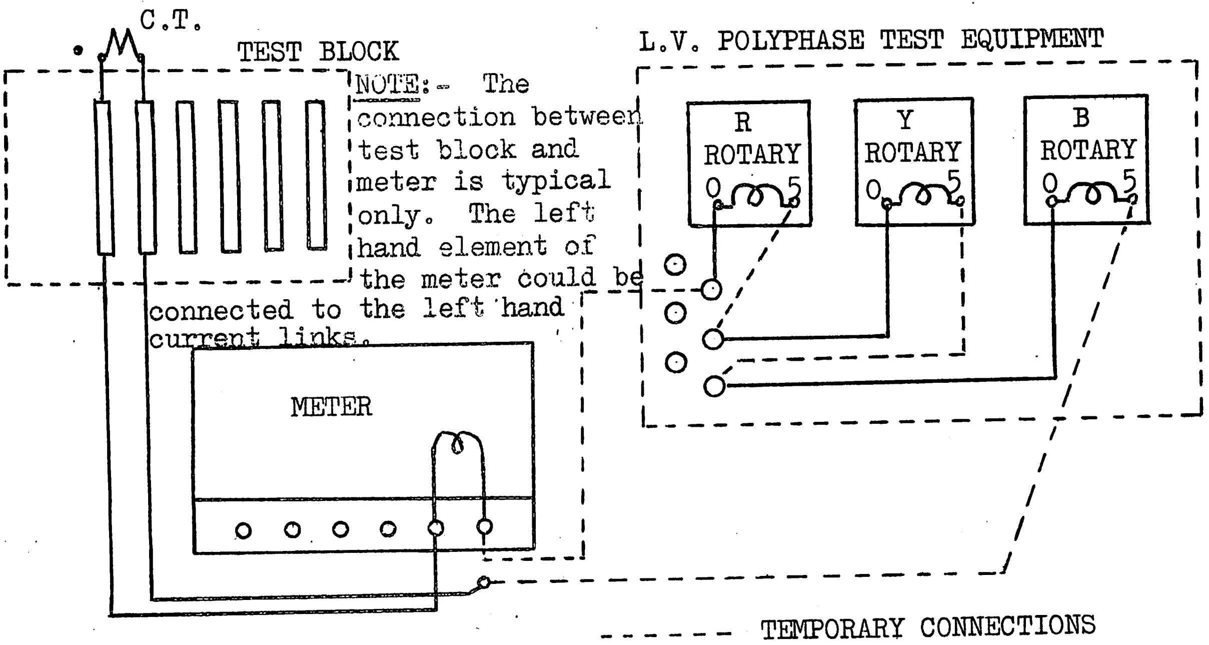
The relative phase angles between voltages and currents of a polyphase system may be determined by a test known as the "Woodson Check", in which the current of one phase is associated with the voltages of each of the three phases in turn. This test is repeated for the current of each of the other two phases providing a total of nine results. From the nine results (3 for each current) a vector diagram may be constructed showing the angular position of each phase current. As each phase current will generally have a component in phase with each of the three voltages, the angular position of the current producing these components is unique.

A test equipment comprising nine individual wattmetric elements would permit all measurements to be made simultaneously, however, satisfactory results may be obtained with three wattmetric elements and recording the three measurements associated with each phase, one phase at a time.

The polyphase test equipment comprises three rotary standard watthour meters and is, therefore, suitable for this purpose.

The equipment should be connected and used as follows:-

1. Remove the connection from the 5 amp. range terminal of each Rotating Standard Watthour Meter (Rotary).
2. Connect the Yellow current non-polarity output terminal to the 5 amp. range terminal of the Red Rotary.
3. Connect the Blue current non-polarity output terminal to the 5 amp. range terminal of the Yellow Rotary.
4. At the test block bridge all current transformers and open the movable links of Yellow and Blue phases.
5. Withdraw the "Red" non-polarity wire from the meter and connect it to the 5 amp. range terminal of the Blue Rotary.
6. Connect the Red non-polarity meter terminal to the Red current non-polarity output terminal of the L.V. Polyphase Test Equipment.
7. Remove the bridge from the Red current links at the test block.
8. Put the P.F. Selector Switch of the L.V. Polyphase Test Equipment in the "Off" position and energise the Equipment (with three phases and neutral) from the test block or meter.
9. Set each Rotary to zero and switch on their voltage circuits.



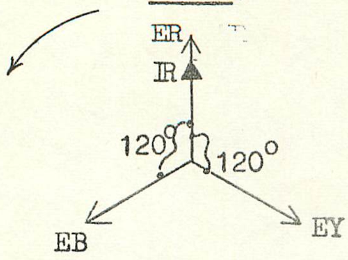
NOTE:- The connection between test block and meter is typical only. The left hand element of the meter could be connected to the left hand current links.

------ TEMPORARY CONNECTIONS

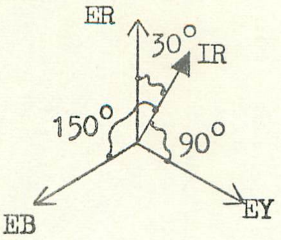
The condition now is that the Red secondary current is passing through each Rotary current coil and is associated with Red, Yellow and Blue voltages respectively. The direction and comparative speed of rotation of the Rotary will depend on the phase angle of these associations, it being assumed that the phase voltages are equal and symmetrical.

Some vector representations for various conditions are shown:-

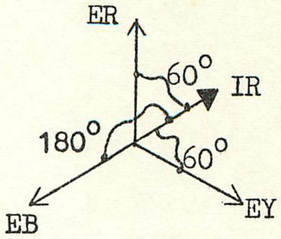
U.P.F.



0.86 LAG P.F.



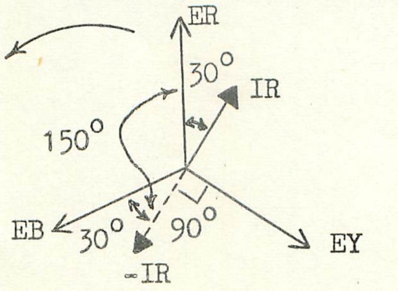
0.5 LAG P.F.



The following tabulation shows the conditions for each Rotary at the various power factors illustrated.

P.F.	ROTARY	PHASE ANGLE, VOLTAGE AND CURRENT	COSINE & SUM OF R.Y.& B.	DIRECTION AND COMPARATIVE SPEED OF ROTATION.	
	Red	0	+1.0)	Forward	1.0
1.0	Yellow	120°	-0.5) = 0	Reverse	0.5
	Blue	120°	-0.5)	Reverse	0.5
	Red	30°	+0.86)	Forward	0.86
0.86 Lag	Yellow	90°	0) = 0	Stopped	0
	Blue	150°	-0.86)	Reverse	0.86
	Red	60°	+0.5)	Forward	0.5
0.5 Lag	Yellow	60°	+0.5) = 0	Forward	0.5
	Blue	180°	-1.0)	Reverse	1.0

The above analysis has shown the respective direction and comparative speed of rotation of each Rotary for known values of power factor. It has also shown that if connections are correct, the sum of the three Rotary readings is equal to zero. It does not prove, however, that the polarity of the current transformer used in the test (Red) is correct, for example assume that the Red current transformer polarity is incorrect and the load power factor is 0.86 lagging.



IR shown lagging ER by 30°.
-IR = IR reversed and leading ER by 150°.
The readings obtained would be:

Red Rotary cos 150° = -0.86)
Yellow Rotary cos 90° = 0) = 0
Blue Rotary cos 30° = +0.86)

When conducting a test of this nature, experience has shown that most satisfactory results can be achieved by switching the voltages on to the Rotaries and switching the voltages off when the most rapidly moving Rotary has completed approximately one half ($\frac{1}{2}$) of a revolution. The three readings are then taken and from these results the position of the current vector can be plotted. Bearing in mind that each Rotary rotates at a rate proportional to its voltage, current and the cosine of the angle between them, and further that since the current is common to each and voltages are assumed to be equal and symmetrical, the rate of rotation (the reading obtained) is proportional to the cosine or the in-phase component.

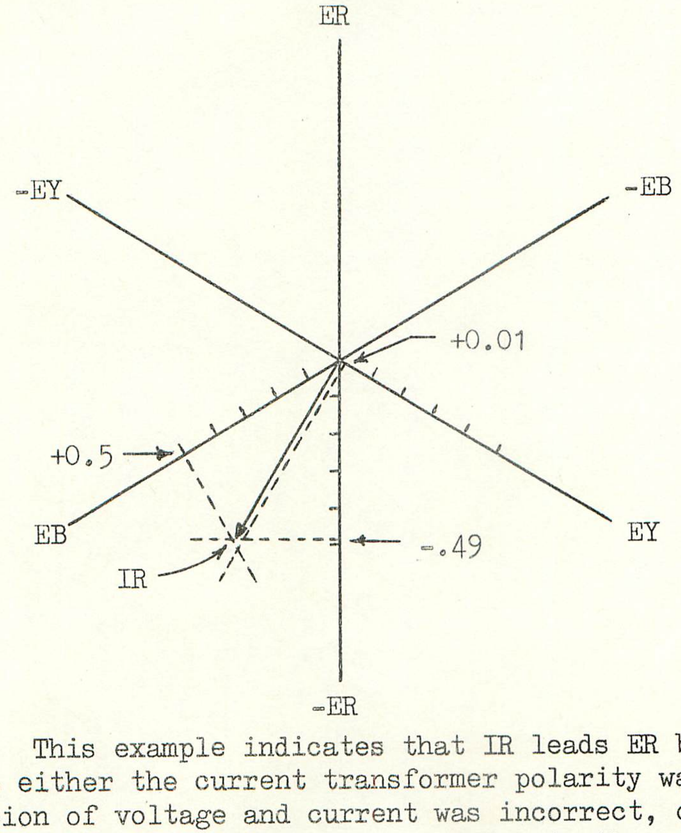
The direction of rotation of the meter under test should be observed; its direction should be the same as that of the Red Rotary.

In general the Red Rotary will always read positive for correct connection. The exception to this would be when a low power factor 415 volt load is connected. The effect of such a load is explained under "General".

Suppose the readings of the Rotaries were as follows:

Red	-0.49 revolutions
Yellow	+0.01 revolutions
Blue	+0.50 revolutions

Plot these values to scale on the appropriate voltage vectors and draw perpendiculars to them. The intersection of the three perpendiculars will give the locus of the current vector as illustrated.



This example indicates that IR leads ER by approximately 150° and that either the current transformer polarity was reversed, the association of voltage and current was incorrect, or the "connection checker" had been incorrectly connected into the circuit.

The angular position of Yellow and Blue currents can be determined repeating the procedure with the "connection checker" connected into Yellow and Blue secondary circuits at the meter. It is not necessary to alter any connections at the L.V. Polyphase Test Equipment for this purpose.

The direction of rotation of the meter should be observed; its direction should be the same as that of the Yellow or Blue Rotary dependent on the phase being investigated at the time.

When Yellow and Blue current vectors are plotted, it should be possible to determine whether, for example in the case of Red current leading by 150°, this is due to reversed polarity or incorrect association of current and voltage.

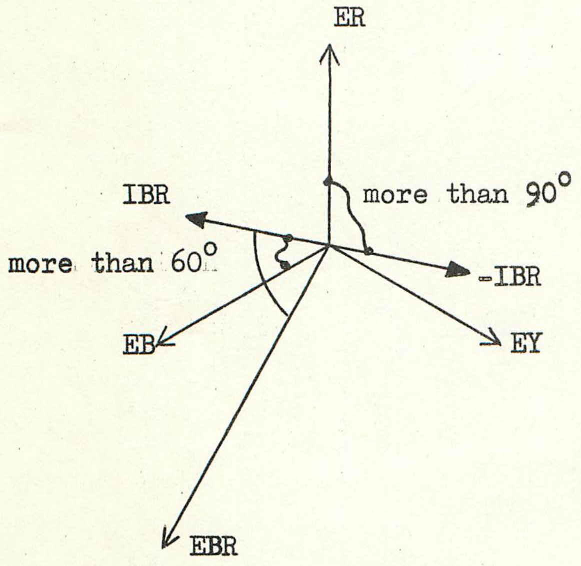
GENERAL.

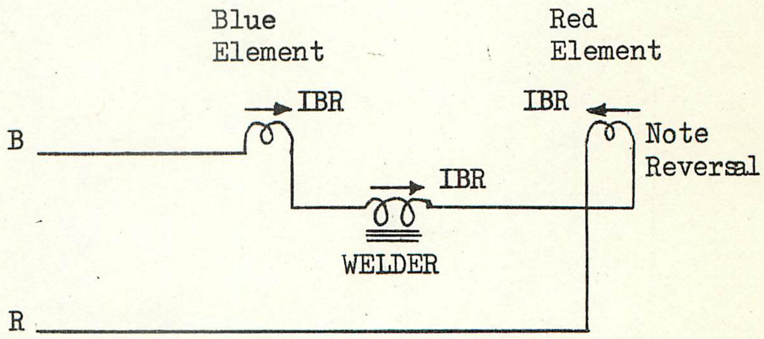
In some cases load may be connected between two phases and the current of such a load could lead or lag the line voltage by almost 90°. As the line voltage is displaced from the phase voltage by 30° the current seen by a particular meter element could be displaced from the voltage of that element by almost 120°.

Industrial and Commercial loads normally operate at lagging power factors. Capacitor load may cause an individual circuit to have a leading power factor but the Council's Service Rules do not permit a customer to operate with a leading power factor.

The type of load which may cause some concern to meter testing personnel is a low power factor 415V load such as electric welding equipment which, when idling, may have a power factor more lagging than 0.5. In large industrial complexes such types of load may be swamped by the general load, but in smaller installations the welding load may, at times, predominate and cause a reversal of one single phase meter or meter element.

In the following diagrams a single phase 415 volt welder is shown connected to Blue and Red phases.





As shown, the line current IBR lags the line voltage EBR by more than 60°. This condition could exist with the welder energised but idling. In the above case the Blue meter or element will see current IBR and voltage EB and will have forward torque.

The Red meter or element will see current IBR and voltage ER and will have reverse torque because the related angle exceeds 90°.

Warren Ashton

023.222.3

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23 August, 1991

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DRAFT TECHNICAL INSTRUCTION NO. 7707 - FIELD TESTING OF LV CURRENT TRANSFORMER METERING

Draft Technical Instruction No. 7707. has been produced to guide field staff in the latest techniques of testing LV current transformer metering, incorporating the following procedures -

a Testing of CT meter connections without a 3A dummy load.

b Testing of Standard kVA Demand metering equipment.

c Testing of the E1 meter.

d On load testing of meter connections using the Woodson check, phase angle comparison method.

Note: Only purpose made short-circuiting devices or lengths of 2.5sq. mm insulated cable must be used such that the size of the devices precludes the installation of terminal covers. The dangerous practice of using sealing wire or self tapping screws to short circuit the CT secondary circuit is to cease.

Staff are reminded of the provisions of TI 7900 - Access To Customers Premises.

The increasing use of screened power cables (RFI protected with foil or semi-conducting plastic layer) makes the practice of cable pricking extremely dangerous and the pricker is not to be used under any circumstances.

The procedures and techniques as outlined in the draft TI 7707 makes redundant the use of prickers and 3A dummy loads. This equipment is to be immediately withdrawn and forwarded to the Customer Supply Training And Instruction Section, Distribution Policy Branch.

Would you please arrange for your staff to implement these procedures prior to the formal Instruction being issued. All staff required to test current transformer metering have been trained in these techniques and issued with the draft Instruction.

A copy of the draft Instruction is attached for your reference.

M G Hartman.

EXECUTIVE MANAGER - DISTRIBUTION POLICY

Attach./